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A. D. MELVIN, CHIEF OF BUREAU.

THE COLD STORAGE OF CHEESE.

(EXPERIMENTS OF 1903-4.)

BY

CLARENCE B. LANE, B. S.,

Assistant Chief of the Dairy Division, Bureau of Animal Industry.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., March 28, 1906.

SIR: I have the honor to transmit the accompanying paper entitled "The Cold Storage of Cheese," being a study of this subject under commercial conditions with a view to solving some of the practical problems involved in this important branch of our trade.

This work, which was carried out during 1903-4, was planned and directed by the late Henry E. Alvord while chief of the Dairy Division of this Bureau. The results have been brought together and prepared for publication by Clarence B. Lane, assistant chief of the Dairy Division. The author gives credit to Duncan Stuart, assistant in dairying, for valuable aid in compiling tables and charts.

This article contains information which is believed to have considerable value for the cheese trade, and I therefore recommend its publication as Bulletin No. 83 in the series of this Bureau.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.



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THE COLD STORAGE OF CHEESE.

INTRODUCTION.

This experiment was planned and conducted by Maj. Henry E. Alvord, late chief of the Dairy Division, and it was practically completed before his death, which occurred October 1, 1904. The results have been brought together and tabulated by the writer in the present bulletin. The general details of the experiment were in charge of William E. Smith, dairy inspector, who was also chairman of the board of scorers. The other judges were B. F. Van Valkenburgh, dairy inspector, and F. P. Swift, representing one of the largest cheese-exporting firms in Montreal and New York. New York was chosen as the place for the investigations, and suitable arrangements were made at a cold-storage warehouse, where rooms were fitted up and the desired temperatures secured.

OBJECT OF THE EXPERIMENT.

The investigations were undertaken to study on a commercial scale and under commercial conditions the influence which different temperatures exert (1) upon the weight of the cheese, (2) upon the quality of the cheese, and (3) the influence of such temperatures in combination with coating the cheese with paraffin. The commercial quality of the stored product was determined by a jury of experts thoroughly in touch with the demands of the market.

PLAN OF THE EXPERIMENT.

About 3 tons of cheese was purchased, of three different types, or sizes, known in the trade as Cheddars, Flats, and Young Americas. The product was as even and uniform in all respects as possible, except for the difference in size and shape of the three types. About one-half of the cheeses were paraffined and the other half remained in their natural condition. Almost the entire quantity was divided into three lots, as evenly as possible in all respects, and these lots were stored at the temperatures of 28°, 34°, and 40° F., respectively. Each contained about 40 or 50 cheeses. The cheeses were examined by a committee of experts and weighed when first placed in storage and every

two months thereafter for a period of eight months. It was further planned to freeze another lot of cheese, much smaller than the lots mentioned above, holding this at a temperature of about 5° F., for the purpose of determining the effect of freezing on the quality. Chemical analyses were made of the cheese before placing in storage to determine its character.

SOURCE, CHARACTER, AND AMOUNT OF THE CHEESE USED.

The cheese selected was all of the firm typical Cheddar variety, made in the States of New York and Wisconsin. For convenience, we will group the lots as follows: Group I—Export Cheddar: *a*, natural; *b*, paraffined. Group II—Flats: *a*, natural; *b*, paraffined. Group III—Young Americas: *a*, natural; *b*, paraffined. Group IV—All the above-named styles, stored at freezing temperature.

The table herewith gives the locations of the factories from which the different lots were secured, and also the size, amount, and score of the cheese purchased.

TABLE I.—*Origin, quantities, and description of cheese used in the experiment.*

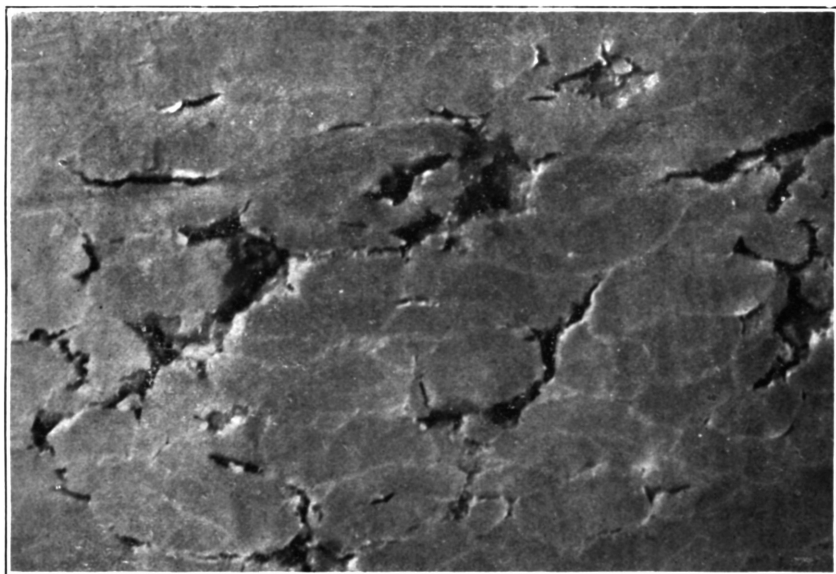
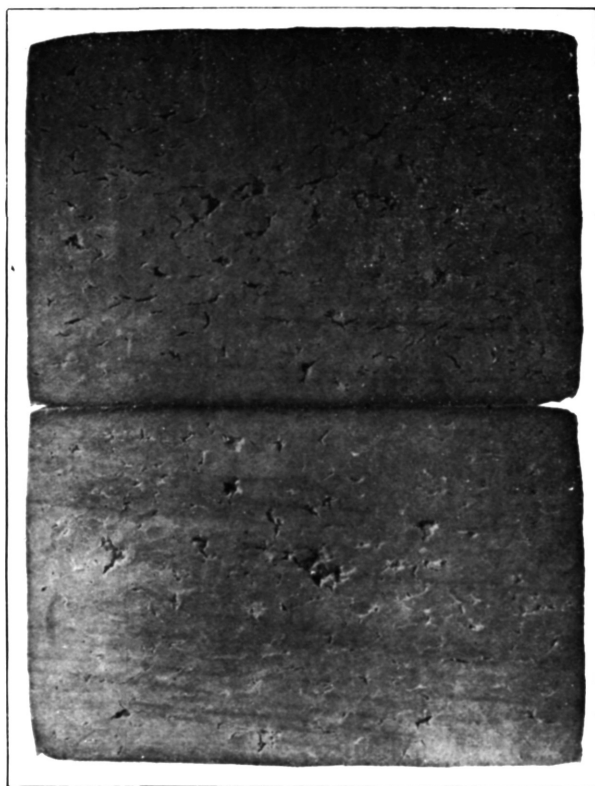
Origin and style.	Number.	Weight.	Flavor.	Make.	Texture.
Group I, Export Cheddar, Fish Creek Factory, St. Lawrence County, N. Y.	51	<i>Lbs. ozs.</i> 3,472 1	Almost perfection.	Fine, close, firm.	Waxy and mellow.
Group II, Flat, Springbrook Factory, Cattaraugus County, N. Y.	51	1,922 12	Fine to perfect.	Fine, close, firm.	Firm, mellow.
Group III, Young America, Valley House Factory, Sheboygan County, Wis.	40	415 11	Fine to perfect.	Firm, close, fairly waxy.	Firm, mellow, waxy.

Origin and style.	Color.	Style, finish.	Surfaces.	Boxing.	Paraffining.
Group I, Export Cheddar, Fish Creek Factory, St. Lawrence County, N. Y.	High, uniform.	Fine..	Smooth, firm, tendency to mold.	Good.	Well done.
Group II, Flat, Springbrook Factory, Cattaraugus County, N. Y.	High to very high, a few mottled.	Fine..	Bright, smooth, firm.	Good.	Well done.
Group III, Young America, Valley House Factory, Sheboygan County, Wis.	Good	Fine..	Bright, smooth, firm.	Good.	Well done.

The cheese was not made specially for this experiment, but was selected from the lots received in New York City from the above-named factories in the regular course of business, and the effort was made to select cheese that was of uniformly high quality.

CHEMICAL ANALYSIS OF THE CHEESE.

A complete chemical analysis was made by the Bureau of Chemistry of two of the styles of cheese (export Cheddars and Flats) in order to determine more accurately their exact character. As these two kinds came from different counties and represent two sections of the State of New York, the results are of interest. They are as follows:



SECTIONS OF CHEDDAR CHEESE BEFORE STORAGE.

[Lower figure shows small section of above cheese at natural size.]

TABLE II.—*Chemical analysis of export Cheddars and Flats.*

Style.	Water.	Fat, by official gravity method.	Fat, by Babcock method.	Approximate casein (N $\times$ 6.37). ^a	Ash.	Total.
Export Cheddar.....	37.76	32.64	Lost.	24.91	3.31	98.62
Flat.....	34.51	35.73	36.50	24.25	3.76	98.25

^a Factor 6.37 is not correct for the nitrogenous matter of a ripened cheese; some of the chief products of ripening call for a larger factor, but in the present state of knowledge we can do no better than use the casein factor 6.37.

TEMPERATURES AT WHICH THE CHEESE WAS STORED.

The cheese was weighed and put in the storage rooms in boxes about two weeks from the time it was made, this being about the usual shipping age of cheese in commercial practice. The temperatures of 28°, 34°, and 40° F. were selected for the reason that the best storage temperatures were believed to range between 28° and 40° F. With any temperature below 28° F. there would be danger of freezing, and on the other hand it has been proved quite conclusively that cheese can not be carried in the best condition at a temperature over 40° F. As a part of the experiment some of the cheese was held at a temperature of 5° F. to note the effect of freezing.

The following is a copy of the score card adopted for the experiments:

[Experiments in storing cheese at low temperatures, United States Department of Agriculture, Bureau of Animal Industry, Dairy Division.]

CHEESE JUDGING.

NUMERICAL AND DESCRIPTIVE SCORE CARD.

Score for cheese (or sample) marked:.....

NUMERICAL SCORE.

Perfection, 100 points.	Make, texture, body, 50 points.	Flavor, 25 points.	Color, 15 points.	Finish, surfaces, 10 points.
Score				

Date:....., 190 . Initials of judge:.....

DESCRIPTIVE SCORE. (Check as found below.)

Make, texture, and body.	Flavor.	Color.	Finish, surfaces.
Perfect Silky	Perfect	Perfect	Perfect.
Smooth Rough	Clean	High	Fine.
Pasty Stiff	Flat	Medium	Good.
Weak Acidity	Fruity	Light	Poor.
Sour Close	Sweet	Spotted	Checked.
Loose	Tainted	Streaked	Damaged.
Holes, mechanical	Weedy	Mottled	
Holes, gas	Tallowy	Natural	

LENGTH OF THE EXPERIMENT.

The cheese was stored in October, 1903, and remained in storage until April 18, 1904, when one-half of the quantity stored at each temperature was placed upon the market, with the exception of that stored at a freezing temperature. The remainder (with the exception of a few cheeses removed for samples) was held until June 20, and then sold. The frozen cheese held at 5° F. was also disposed of in June.

DETAILS OF THE STORAGE.

As already stated, arrangements were made with a refrigerating company of New York City to provide storage and take care of these different lots of cheese. Rooms were arranged in which the temperature could be controlled and kept at 40°, 34°, and 28° F. Automatic tabulators were provided in each room to show continuously the state of the temperature. Close watch was kept of the refrigerating rooms, and the temperatures were noted at least three times daily to see that the thermometers were running properly and that the temperatures were normal. (See fig. 1.)

The different lots of cheese were distributed in the different rooms as indicated in the following table:

TABLE III.—*Distribution of cheese at different temperatures.*

Style of cheese.	Cheese at 40° F.		Cheese at 34° F.		Cheese at 28° F.		Cheese at 5° F.	
	Num-ber.	Weight.	Num-ber.	Weight.	Num-ber.	Weight.	Num-ber.	Weight.
		<i>Lbs. oz.</i>		<i>Lbs. oz.</i>		<i>Lbs. oz.</i>		<i>Lbs. oz.</i>
Cheddar, natural.....	8	546 2	8	545 4	8	550 4	2	135 13
Cheddar, paraffined.....	8	547 13	8	540 6	8	538 9	1	67 14
Flat, natural.....	8	299 14	8	304 10	8	299 6	2	74 7
Flat, paraffined.....	8	299 12	8	296 8	8	310 11	1	37 8
Young America, natural.....	6	61 10	6	61 10	6	61 14	2	20 13
Young America, paraffined.....	6	62 14	6	62 7	6	68 6	2	20 17

SYSTEM OF REFRIGERATION.

The cheese was stored in small rooms specially built for this experiment. Cold air was taken into these rooms from a main cooling room lined with brine pipes. The temperature was governed by sliding doors, which were opened or closed as became necessary in order to hold the different rooms at the required temperature. In the 40-degree room an automatic electric heater was used to assist in regulating the temperature.

RESULTS OF THE EXPERIMENTS.

In presenting the results of these experiments only the summaries will be given. The main points naturally arrange themselves in two distinct parts. Under Part I will be discussed the loss in weight

sustained at the different temperatures, and Part II will include the effect of the different temperatures on the quality of the cheese stored.

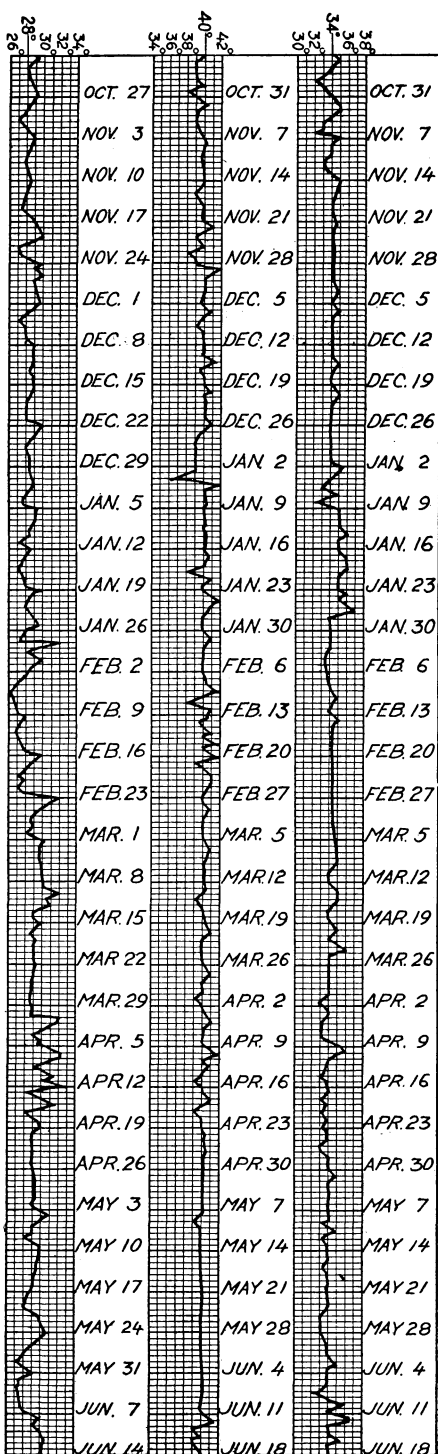
I. LOSS IN WEIGHT AT THE DIFFERENT TEMPERATURES.

So few data are available on this subject that the question of shrinkage was made the chief feature of this experiment. The temperatures employed were somewhat lower than those used in ordinary practice. It is therefore of interest to ascertain whether these temperatures possess any advantage over those usually employed. Heavy losses are a great tax to the producer; therefore any factor which can be used to decrease the loss adds so much to the receipts from the milk produced.

DETAILS OF WEIGHING THE CHEESE.

The cheese was all carefully weighed before being placed in storage, records being taken to the nearest ounce. In order that the results might be practical, it was arranged to note at stated periods the losses that occurred. The cheese was therefore weighed every two months from the time it was put in storage, or four times during the period of eight months. The accompanying charts (figs. 2, 3, and 4), showing these data, indicate the loss at any one of these periods.

FIG. 1.—Record of temperature variations during entire storage period.



FACTORS INFLUENCING LOSS IN WEIGHT.

There are several factors which affect the rate of shrinkage of cheese in storage, among which may be mentioned temperature, size, and form of cheese, protection of the external surface by paraffin, moisture content of the cheese, and humidity of the air. In this experiment, however, only the first three were studied, and the results will be discussed in relation to each other in the order given.

A. TEMPERATURE.

It has already been shown in Table I that three common types of cheese were selected for studying the rate of loss in storage at temperatures of 40°, 34°, and 28° F. The styles and weights used were: Fifty-one Cheddars, weighing 3,472 pounds 1 ounce; 51 Flats, weighing 1,922 pounds 12 ounces; and 40 Young Americas, weighing 415 pounds 11 ounces, making a total of 5,810 pounds 8 ounces.

The following table shows the losses for each 100 pounds of cheese of the different types at each inspection:

TABLE IV.—Pounds loss per 100 pounds of cheese.

NATURAL.					
Style of cheese and tempera- ture.	Date stored.	Date of inspection.			
		Dec. 14, 1903 (63 days).	Feb. 15, 1904 (126 days).	Apr. 14, 1904 (185 days).	June 15, 1904 (247 days).
Cheddar:					
40° F.	Oct. 12, 1903	2.27	3.68	4.68	5.87
34° F.	do	1.62	2.88	4.18	5.12
28° F.	do	.93	1.48	1.81	2.88
Flat:					
40° F.	do	1.62	2.75	3.90	5.53
34° F.	do	1.15	2.30	3.21	4.37
28° F.	do	.83	1.32	1.71	2.19
Young America:		(49 days.)	(112 days.)	(171 days.)	(233 days.)
40° F.	Oct. 26, 1903	2.37	4.73	6.81	9.34
34° F.	do	1.21	3.03	5.02	6.95
28° F.	do	.61	1.82	2.83	4.25

PARAFFINED.					
Style of cheese and tempera- ture.	Date stored.	Date of inspection.			
		Dec. 14, 1903 (63 days).	Feb. 15, 1904 (126 days).	Apr. 14, 1904 (185 days).	June 15, 1904 (247 days).
Cheddar:					
40° F.	Oct. 12, 1903	0.91	1.64	2.02	3.19
34° F.	do	.27	.72	1.34	1.36
28° F.	do	.19	.37	.61	1.27
Flat:					
40° F.	do	.49	1.14	1.46	2.17
34° F.	do	.49	.97	1.33	1.63
28° F.	do		.32	.68	1.02
Young America:		(49 days.)	(112 days.)	(171 days.)	(233 days.)
40° F.	Oct. 26, 1903		.60	2.00	2.38
34° F.	do	.59	1.18	1.58	2.11
28° F.	do		.60	1.17	1.45

It will be observed that the losses sustained by the different types are greater at 40° F. than at either of the other temperatures. During the period of 247 days the losses for the Cheddars and Flats at

40° F. were 5.87 and 5.53 per cent, respectively, while for the Young Americas for the slightly shorter period of 233 days the loss was 9.34 per cent. At 34° F. the losses were 5.12, 4.37, and 6.95 per cent, respectively, for the same periods, and at 28° F., 2.88, 2.19, and 4.25 per cent. In case of all three types, therefore, the use of the 28° F. temperature for storing prevented over one-half of the loss in weight, as compared with 40° F. The saving, therefore, for a factory making 500 pounds of cheese daily would amount to at least 15 pounds of cheese, or \$1.50 per day for the season when Cheddars and Flats are made, and in case of the Young Americas the saving would be even greater, provided the cheese were placed in storage about two weeks from the hoop, as was the case in this experiment.

The losses at periods of 185, 126, and 63 days are also shown, and will assist the dealer in determining at what stage of storage he can most profitably dispose of his product.

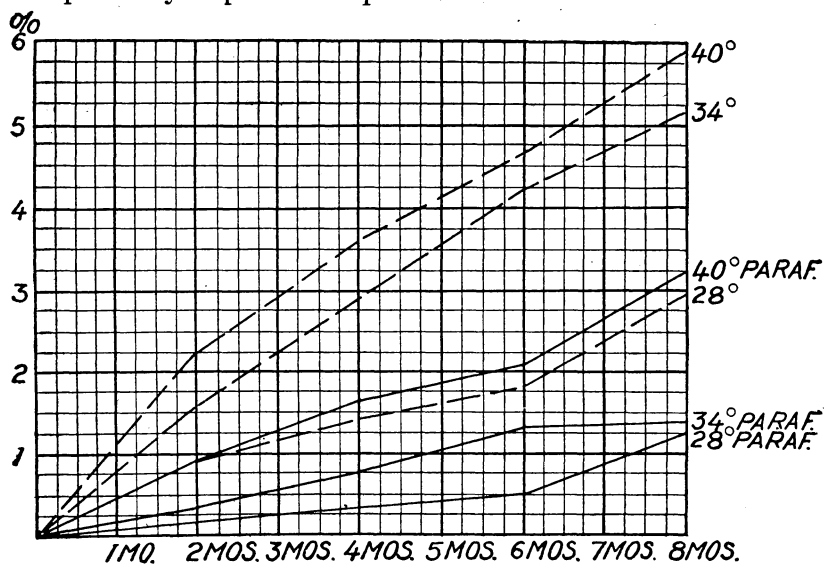


FIG. 2.—Group I, Cheddars. Loss in weight for 8 months. (Broken lines represent natural cheese, solid lines paraffined cheese.)

The difference in the amount of shrinkage was more marked between the temperatures of 28° and 34° F. than between the temperatures of 34° and 40° F.

In order to permit a more ready comparison of the above data, the same are presented in graphic form in figs. 2, 3, and 4.

B. SIZE AND FORM.

The average weight of the Cheddar type of cheese in this experiment was 68 pounds, of the Flats 37 pounds, and of the Young Americas 10.4 pounds. By comparing figs. 2, 3, and 4, it is evident that at 40° F. there was not a great difference in the loss between the Cheddars

and the Flats, which amounted to 5.87 and 5.53 per cent, respectively, for the eight months, while the Young Americas lost 9.34 per cent. The charts of the other temperatures show a similar variation. As pointed out by Babcock and Russell^a the loss in weight during the curing of cheese is not due entirely to evaporation:

A cheese in curing is constantly breathing out carbon dioxide, the same as any living organism, due to the development of micro-organisms (bacterial growth within the cheese, as well as molds on the surface).

It is believed that the difference in the losses between the different types of cheese, as shown in the illustrations, is due largely to the difference in size, the weight of the Young Americas being less than one-sixth of that of the Cheddars.

C. PARAFFINING.

A suitable apparatus for paraffining may be described as follows: The framework for use in hoisting and lowering the cheese into the tank consists of four posts extending from floor to ceiling, two of them at one end 6 inches apart, with a similar pair 8 feet away. Between these pairs of posts is a tank 7 feet long, 2 feet wide, and 2 feet deep. A space about 4 inches wide and running lengthwise of the interior of the tank is partitioned off. In this is placed the unmelted paraffin as fast as a supply is needed. This entire tank is inclosed by a pocket tank, there being about one-fourth of an inch space between the tanks at the sides and ends, and one-half to three-fourths of an inch at the bottom. To either side of this pocket is attached about halfway up a 2½-inch water pipe, connected with a tank heated by a stove. It is so arranged that the hot water flows all around and under the tank, thereby heating the paraffin to the boiling point. The best temperature is obtained when the water is kept boiling. Inside and at each end of the main structure is attached a frame over the center of the vat, on which the cheeses are placed edgewise before being lowered into the tank. They are let down by hand with a small rope run over a pulley, a counterbalance with transferable weights being used. It can be balanced to carry two, four, or six cheeses.

The time required for proper paraffining varies according to the condition of the cheese. The cheeses are lowered slowly until covered. They are then allowed to remain fifteen seconds, when they are raised out of the paraffin and allowed to drip until the paraffin on the surface is hard. This usually requires about fifteen seconds.

By this plan of paraffining no odor is given off and the paraffin is left transparent and without smell or taste. An apparatus sometimes used for this purpose heats the paraffin by means of steam pipes placed

^aBulletin 49, Bureau of Animal Industry, U. S. Department of Agriculture.

in the bottom of the tank, but this plan frequently "burns" the paraffin, causing it to take on a very offensive odor and flavor. This bad flavor is transmitted to the cheese and detracts from its value. A 35-pound cheese should carry from half an ounce to 2 ounces of paraffin and a 70-pound cheese 3 to 4 ounces. The apparatus outlined above has proved practical and turns out a very attractive product.

One-half of the cheeses in each group were paraffined (see Table IV) by the above method, the object being to determine how far this treatment retards the rate at which cheese loses its moisture. Table IV gives the data as to the percentage of loss in both the paraffined and unparaffined (control) lots. The results are also presented in figs. 2, 3, and 4.

The application of paraffin to cheese of the Cheddar type stored at 40° F. resulted in reducing the loss to little more than one-half that of the unparaffined cheese; at 34° F. nearly three-fourths of the loss was

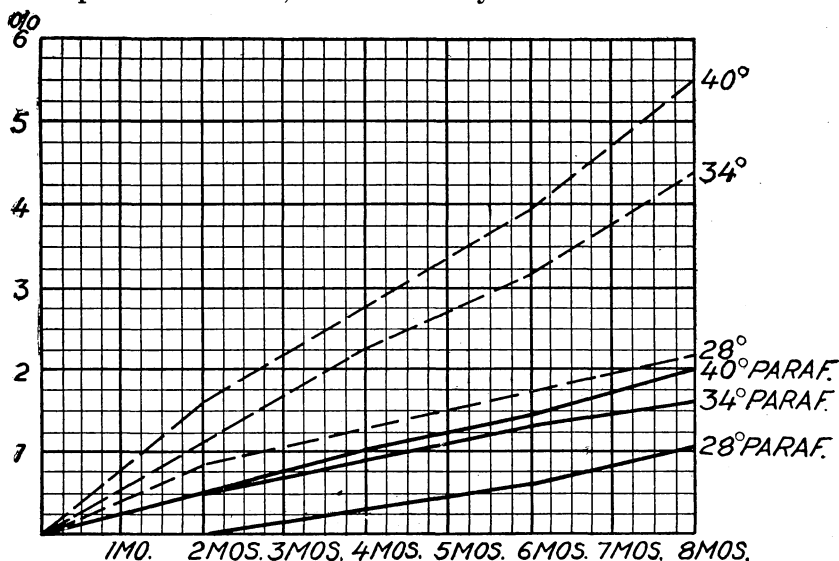


FIG. 3.—Group II, Flats. Loss in weight for 8 months.

prevented, while the losses in the paraffined cheese at 28° F. were reduced almost to a minimum. This was also the case with the unparaffined cheese at this latter temperature, although the losses were still more than twice as great where the cheese was not treated with paraffin.

The relation between the losses in the paraffined and unparaffined cheese in the Flats is similar to that observed in the Cheddars. The curves show that at 40° F. more than one-half of the loss was prevented by coating with paraffin during eight months' storage, while at 34° F. nearly two-thirds of the loss was prevented, and at 28° F. over one-half. Both the paraffined and unparaffined lots in this group lost even less at the latter temperature than did the preceding group.

As would naturally be expected, the Young America type, being the smallest, showed the greatest loss, and fig. 4 demonstrates very clearly the advisability of coating cheese with paraffin, particularly if the cheese handled is of this type. It will be seen from the diagram that there was a very rapid and constant loss in the case of the unparaffined cheese from the date it was placed in storage. This amounted to 9.34 per cent during the eight months' period at the 40°

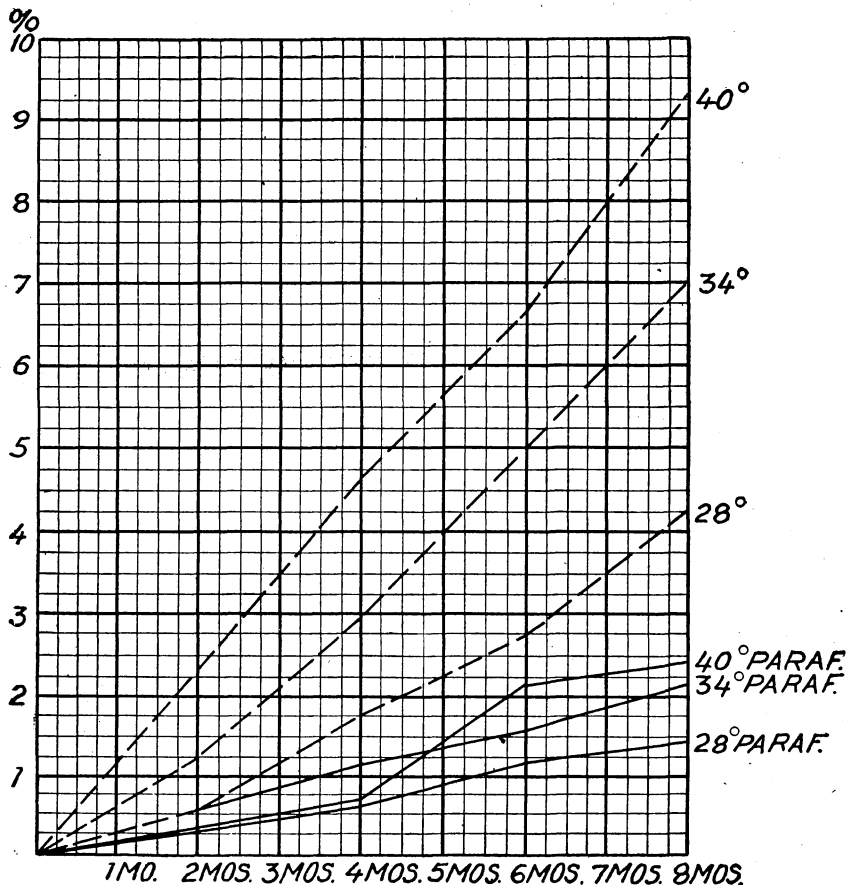
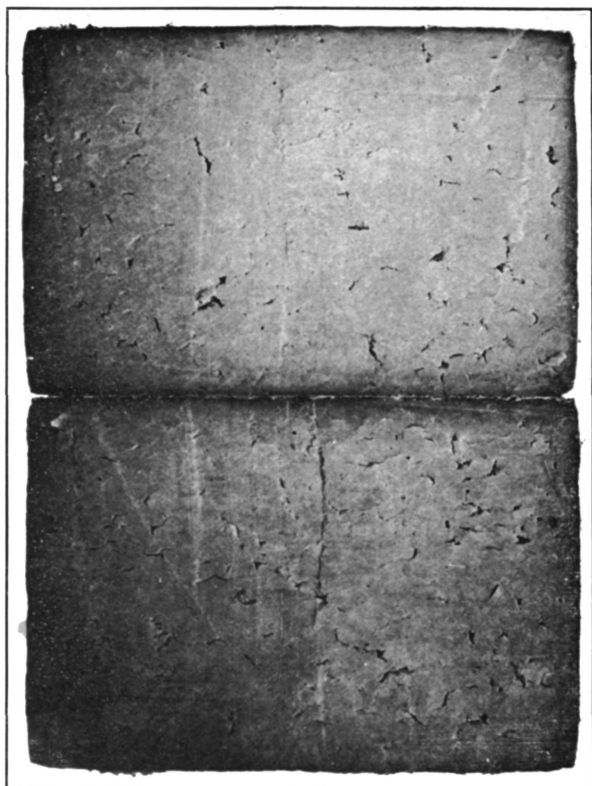


FIG. 4.—Group III, Young Americas. Loss in weight for 8 months.

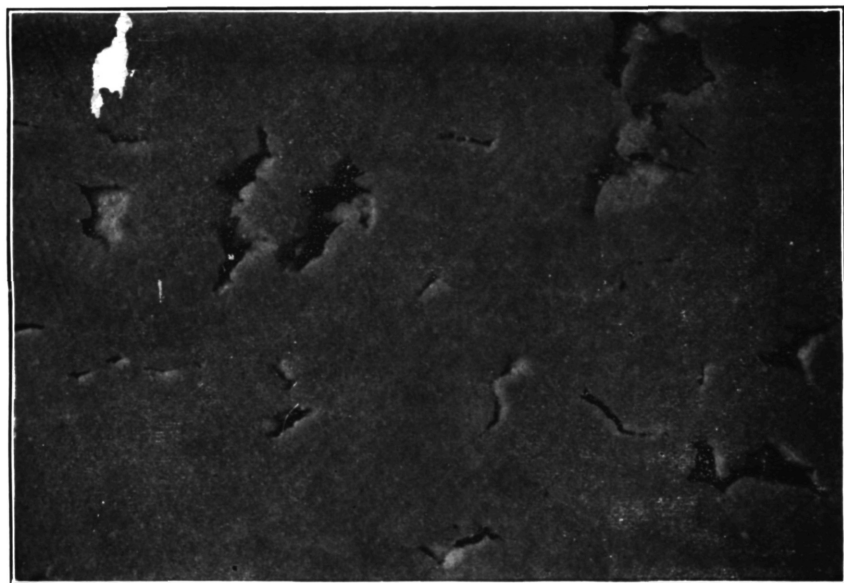
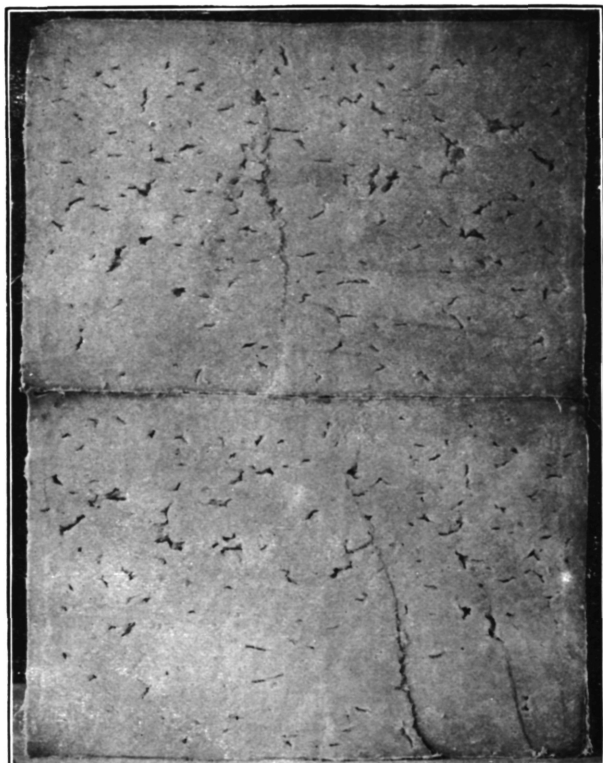
F. temperature. By coating with paraffin the loss at this temperature was reduced to 2.38 per cent, or nearly three-fourths. At 34° F. two-thirds of the loss was prevented, and at 28° F. practically the same result was noted.

No further argument is needed to demonstrate the value of paraffin as a factor in preventing shrinkage in stored cheese. This, together with the use of low temperatures, results in a great saving to the dealer, and enables him to pay the factory better prices, and the factory in turn to pay more to the producer.



SECTIONS OF CHEDDAR CHEESE AFTER EIGHT MONTHS' STORAGE AT 28° F. (NOT PARAFFINED).

[Lower figure shows small section of above cheese at natural size.]



SECTIONS OF CHEDDAR CHEESE AFTER EIGHT MONTHS' STORAGE AT 28° F.
(PARAFFINED).

[Lower figure shows small section of above cheese at natural size.]

II. EFFECT OF TEMPERATURE ON QUALITY OF CHEESE IN STORAGE.

In order to determine the effect of different temperatures on the quality of cheese and to ascertain the length of time required to develop the product to its best selling condition, cheese was inspected and scored by commercial experts once in two months during the period of storage. The averages of the scores of the three judges at the different examinations are presented in Table V (p. 20).

DESCRIPTION OF CHEESE AT TIME OF STORING.

Group I, Cheddar type, was represented by 51 cheeses, weighing a total of 3,472 pounds and 1 ounce, manufactured by the Fish Creek factory, St. Lawrence County, N. Y.; shipped from there on October 5, 1903, and received at New York City on October 9 in the regular course of business. Twenty-five of them were paraffined on October 10.

Description of cheese: Flavor, as nearly perfection as possible; make, fine, close, and firm, showing a few curd fissures; texture, waxy and mellow; color, a strong shade of colored cheese, very uniform; style and finish, fine; surfaces, smooth and firm; the natural cheese had a slight tendency to mold, owing to damp weather; boxing, good; paraffining, very well done; weights, average about 68 pounds. For numerical score, see Table V.

Group II, Flats, was represented by 51 cheeses, weighing 1,922 pounds 12 ounces, manufactured at the Springbrook factory, Cattaraugus County, N. Y.; shipped from there October 3, 1903, and received in New York City October 5 in the regular course of business. Twenty-five of them were paraffined on October 8.

Description of cheese: Flavor, fine to perfect; make, fine, close, firm (one loosely packed in hoop); texture, firm, mellow; color, high to very high, a few inclined to mottle; style and finish, fine; surface, bright, smooth, and firm; boxing, good; paraffining, very well done; weights, average about 38 pounds. For numerical score, see Table V.

Group III, Young Americas, was represented by 40 cheeses, weighing 415 pounds 11 ounces, manufactured at Valley House factory, Sheboygan County, Wis.; shipped from there on October 19, 1903, and received at New York City October 23 in the regular course of business. One-half of this lot was paraffined October 24.

Description of cheese: Flavor, fine to perfect; make, fine, close, fairly firm; texture, firm, mellow, waxy; color, good; style and finish, fine; surfaces, bright, smooth, firm; boxing, good; paraffining, well done; weights, average about 10½ pounds. For numerical score, see Table V.

RESULT OF FIRST SCORING.

The first scoring took place December 14, 1903, 63 days after placing in storage for the Cheddars and Flats, and 49 days for the Young Americas.

Group I, Cheddars.—At the 40° F. temperature all the cheese was found to be in fine condition, quite equal to that when stored, while at 34° and 28° F. there was some mold on the tops and sides of the cheeses not paraffined. The 28° F. product was highest in both flavor and texture and perfect in color and finish, scoring a total of 99.5. The 34° F. cheese scored 99.1, and the 40° F. cheese 99.

Group II, Flats.—These were slightly moldy at the 28° and 34° F. temperatures, while at 40° F. they presented a good appearance. The judges reported that this group seemed to be developing a winterish flavor, undoubtedly resulting from the low temperature, although this was not noticeable in either the Cheddars or the Young Americas. This style also scored its highest on all points at the 28° F. temperature, the total being 97. At 34° F. the cheese was marked down 3 points for color. The total score at 40° F. was 95.2.

Group III, Young Americas.—These showed some mold at all three temperatures. It is rather remarkable that they scored the same at all temperatures on all four points, including texture, flavor, color, and finish, the total being 99.7.

Group IV, stored at 5° F.—These cheeses were frozen solid, showing ice on the surfaces, and it was impossible to bore them with heavy triers. Near the end of the experiment, however, they were thawed out and scored, the result of this scoring being given elsewhere. At the first inspection the surfaces and sides of the cheese were wrinkled and cracked, owing to the action of the cold.

RESULT OF SECOND SCORING.

The second commercial scoring took place February 15, 1904, at the end of 126 days for the Cheddars and Flats and 112 days for the Young Americas.

Group I, Cheddars.—The cheese in the 40° F. room was found to be in almost perfect condition, which was rather a surprise, particularly in case of that not paraffined. The cheese was bright and had no particular appearance of being cold stored. The average of the scores of the judges gave the 40° F. product 99.3, which is 0.3 higher than the scoring of the 28° F. cheese and 1.5 higher than that of the cheese stored at 34° F. It will be remembered that at the first scoring the 28° F. Cheddars scored the highest; the difference in the scores, however, is not great. At 28° and 34° F. the cheese was more or less moldy, and at the latter temperature 1.2 points were taken off for flavor.

Group II, Flats.—This class of cheese showed some deterioration in flavor and color in all the rooms, which indicated that there was some chemical or latent defect in them which could not be accounted for without chemical analysis. The highest score, 95.2, was given to the 40° F. cheese, as in the case of the Cheddars, while the 28° F. cheese received 94, and the 34° F. product 93.1.

Group III, Young Americas.—This was the only kind which showed any mold at 40° F. at this trial. Aside from the mold, however, the cheese was almost perfect, and scored 99. At 34° and 28° F. the cheeses were quite moldy and a little off in flavor, scoring 97.5 and 96.8, respectively.

RESULT OF THIRD SCORING.

The third commercial scoring took place April 14, 1904, at the end of 185 days for the Cheddars and Flats and 171 days for the Young Americas. All of the cheeses at this scoring, with the exception of those coated with paraffin, were covered more or less with mold.

Group I, Cheddars.—As was the case at the second jury trial, the 40° F. cheese scored highest—99.3—the only deduction from perfect score being on point of texture. At the temperatures of 34° and 28° F. the cheese was quite heavily covered with mold. The judges gave them scores of 97.1 and 97, respectively.

Group II, Flats.—As in the last test, this style of cheese was found to be considerably off in flavor and color at all of the temperatures. That stored at 34° F. was given the highest score—93.4—while the 40° and 28° F. cheese was scored 92.8 and 88.8, respectively.

Group III, Young Americas.—The 34° F. cheese of this type scored highest—98.2—as was the case with the Flats, while the 40° F. product followed closely with 98.1 points, and the 28° F. product scored 96, the latter being marked down for flavor and texture as well as finish.

RESULT OF FOURTH SCORING.

The fourth commercial scoring took place June 15, 1904, 247 days after the cheese was placed in storage in the case of the Cheddars and Flats and 233 days in the case of the Young Americas.

Group I, Cheddars.—The cheese scored remarkably high considering the length of time it had been in storage. The judges gave the cheese at 40° F., 49.5 for texture, 25 for flavor, 15 for color, and 9.3 for finish, making a total of 98.8. This is 1.3 points higher than it scored when first placed in storage. At 34° F. the total score was 98.2 and at 28° F. 96.2.

Group II, Flats.—For some reason this class of cheese scored highest at 34° F., the judges giving it a total of 95.2. The cheese at 40° F. was next with a score of 92.3, and the 28° F. cheese last with a score of 88.3. It will be noted that this style of cheese scored less at the fourth scoring than when it was placed in storage, and, as previously stated, this was probably due to some defect in the making.

Group III, Young Americas.—These held their quality remarkably well, scoring for 40°, 34°, and 28° F., 97.9, 97.5, and 96.3, respectively, against 98.8, 98, and 98.1 at the time the cheese was placed in storage. The greatest deterioration was in the appearance or finish of the cheese and in the flavor; but as the lowest score for all temperatures was 97.5 points, it is rated as high quality even after eight months' storage.

The following tabulation is deduced from the detailed numerical scores made by the three judges, showing the average scores as to texture, flavor, color, and finish (surfaces):

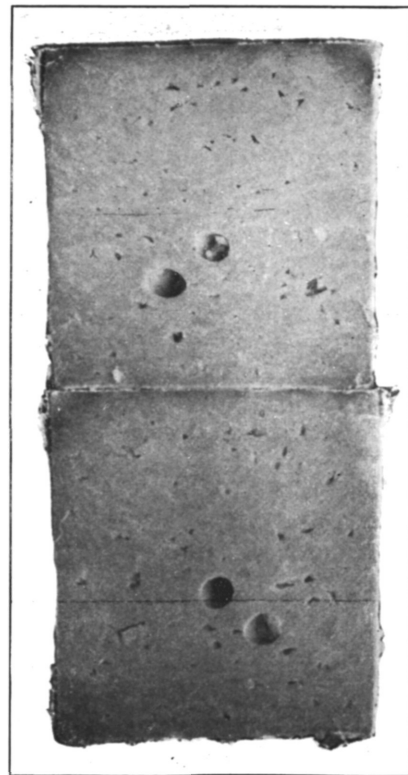
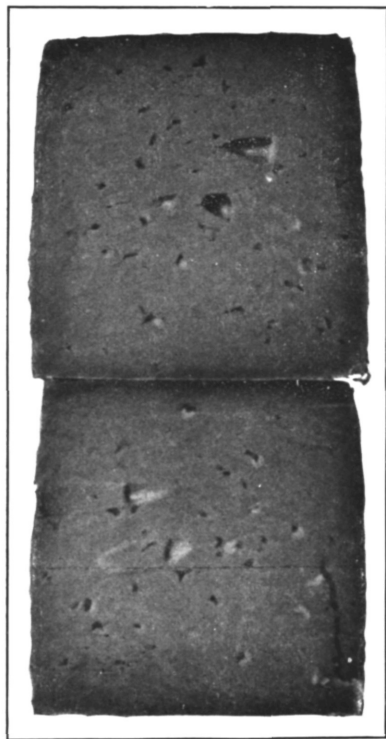
TABLE V.—*Summary of the scoring.*

AT 40° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	48.5	24.0	15.0	10.0	97.5
	Dec. 14, 1903	49.7	24.3	15.0	10.0	99.0
	Feb. 15, 1904	49.3	25.0	15.0	10.0	99.3
	Apr. 14, 1904	49.3	25.0	15.0	10.0	99.3
	June 15, 1904	49.5	25.0	15.0	9.3	98.8
Paraffined	Oct. 12, 1903	49.7	25.0	15.0	10.0	99.7
	Dec. 14, 1903	49.8	24.8	15.0	10.0	99.6
	Feb. 15, 1904	49.3	24.3	15.0	10.0	98.6
	Apr. 14, 1904	49.3	24.7	15.0	10.0	99.0
	June 15, 1904	49.3	25.0	15.0	10.0	99.3
Flat:						
Natural	Oct. 12, 1903	48.1	24.7	13.4	10.0	96.2
	Dec. 14, 1903	48.8	23.0	13.4	10.0	95.2
	Feb. 15, 1904	49.4	23.3	12.5	10.0	95.2
	Apr. 14, 1904	48.9	23.2	10.7	10.0	92.8
	June 15, 1904	48.3	23.3	11.5	9.2	92.3
Paraffined	Oct. 12, 1903	48.7	24.6	13.7	10.0	97.0
	Dec. 14, 1903	49.5	23.7	13.0	10.0	96.2
	Feb. 15, 1904	49.1	21.7	13.0	10.0	93.8
	Apr. 14, 1904	48.8	21.4	12.1	9.9	92.2
	June 15, 1904	48.5	23.1	11.5	9.2	92.3
Young America:						
Natural	Oct. 26, 1903	49.0	25.0	14.8	10.0	98.8
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	25.0	15.0	9.7	99.0
	Apr. 14, 1904	49.3	25.0	15.0	8.8	98.1
	June 15, 1904	49.3	24.7	15.0	8.9	97.9
Paraffined	Oct. 26, 1903	48.8	24.2	15.0	10.0	98.0
	Dec. 14, 1903	50.0	24.5	15.0	10.0	99.5
	Feb. 15, 1904	49.3	25.0	15.0	10.0	99.3
	Apr. 14, 1904	49.3	23.8	15.0	10.0	98.1
	June 15, 1904	49.3	24.3	15.0	9.7	98.3

AT 34° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	49.7	24.8	15.0	10.0	99.5
	Dec. 14, 1903	49.8	24.4	15.0	9.9	99.1
	Feb. 15, 1904	48.8	24.3	15.0	9.7	97.8
	Apr. 14, 1904	49.2	24.3	15.0	8.6	97.1
	June 15, 1904	49.3	24.9	15.0	9.0	98.2
Paraffined	Oct. 12, 1903	49.5	24.5	15.0	10.0	99.0
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.0	24.3	15.0	10.0	98.3
	Apr. 14, 1904	49.3	24.5	15.0	9.9	98.7
	June 15, 1904	49.1	24.9	15.0	10.0	99.0
Flat:						
Natural	Oct. 12, 1903	48.9	24.8	13.8	10.0	97.5
	Dec. 14, 1903	49.3	23.5	12.0	9.9	94.7
	Feb. 15, 1904	48.6	22.8	12.0	9.7	93.1
	Apr. 14, 1904	48.7	23.3	12.0	9.4	93.4
	June 15, 1904	48.9	23.5	14.0	8.8	95.2
Paraffined	Oct. 12, 1903	48.5	25.0	14.0	10.0	97.5
	Dec. 14, 1903	49.2	23.2	12.1	9.8	94.3
	Feb. 15, 1904	48.7	22.2	12.0	9.8	92.7
	Apr. 14, 1904	48.7	22.7	10.0	9.7	91.1
	June 15, 1904	48.9	23.0	10.5	9.3	91.7
Young America:						
Natural	Oct. 26, 1903	48.7	24.3	15.0	10.0	98.0
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	23.5	15.0	9.7	97.5
	Apr. 14, 1904	49.3	24.9	15.0	9.0	98.2
	June 15, 1904	49.2	24.5	15.0	8.8	97.5
Paraffined	Oct. 26, 1903	48.7	24.1	15.0	10.0	97.8
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	24.2	15.0	10.0	98.5
	Apr. 14, 1904	49.3	24.3	15.0	10.0	98.6
	June 15, 1904	49.3	24.5	15.0	9.7	98.5



SECTIONS OF "YOUNG AMERICA" CHEESE AFTER EIGHT MONTHS' STORAGE AT 40° F.

[Cheese on left not paraffined; cheese on right paraffined.]

TABLE V. -- *Summary of the scoring*—Continued.

AT 28° F.

Style and condition of cheese.	Date of score.	Texture.	Flavor.	Color.	Finish.	Total score.
Cheddar:						
Natural	Oct. 12, 1903	49.5	24.1	15.0	10.0	98.6
	Dec. 14, 1903	50.0	24.5	15.0	10.0	99.5
	Feb. 15, 1904	49.3	25.0	15.0	9.7	99.0
	Apr. 14, 1904	49.2	24.7	15.0	8.1	97.0
	June 15, 1904	49.0	24.2	15.0	8.0	96.2
Paraffined	Oct. 12, 1903	49.2	24.1	15.0	10.0	98.3
	Dec. 14, 1903	50.0	24.1	15.0	10.0	99.1
	Feb. 15, 1904	49.7	25.0	15.0	10.0	99.7
	Apr. 14, 1904	49.2	24.3	15.0	9.5	98.0
	June 15, 1904	49.0	24.2	15.0	9.8	98.0
Flat:						
Natural	Oct. 12, 1903	48.7	24.6	14.9	10.0	98.2
	Dec. 14, 1903	49.7	23.6	13.7	10.0	97.0
	Feb. 15, 1904	48.8	23.4	12.0	9.8	94.0
	Apr. 14, 1904	48.4	22.7	10.0	7.7	88.8
	June 15, 1904	48.2	23.0	10.0	7.1	88.3
Paraffined	Oct. 12, 1903	48.4	24.5	13.8	10.0	96.7
	Dec. 14, 1903	49.9	23.8	12.0	10.0	95.7
	Feb. 15, 1904	48.6	23.2	12.0	10.0	93.8
	Apr. 14, 1904	48.5	23.2	13.5	9.7	94.9
	June 15, 1904	48.3	22.5	10.0	8.9	89.7
Young America:						
Natural	Oct. 26, 1903	48.8	24.3	15.0	10.0	98.1
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	22.8	15.0	9.7	96.8
	Apr. 14, 1904	49.2	23.5	15.0	8.3	96.0
	June 15, 1904	49.3	24.1	15.0	7.9	96.3
Paraffined	Oct. 26, 1903	48.9	24.6	15.0	10.0	98.5
	Dec. 14, 1903	50.0	24.7	15.0	10.0	99.7
	Feb. 15, 1904	49.3	23.5	15.0	10.0	97.8
	Apr. 14, 1904	49.1	23.6	15.0	10.0	97.7
	June 15, 1904	49.3	24.3	15.0	9.4	98.0

INFLUENCE OF PARAFFIN ON THE QUALITY OF CHEESE IN STORAGE.

The use of paraffin on cheese to prevent the growth of mold, particularly when the cheese is stored at low temperatures, is now a common practice. It is generally agreed that the paraffin should not be applied until the cheese is ten days or two weeks old, as it is better to give time for the surface to dry. It has been an open question, however, whether the quality of the cheese so treated was improved or deteriorated. The prejudice which has existed among some retailers against the use of paraffin is gradually disappearing, and it may be said that many of the objections against the practice are quite groundless. The greatest objection has come from dealers who claim a considerable loss in weight in removing the cloths from the cheese. The commissioner of agriculture and dairying of Canada, after conducting some experiments along this line, sums up the matter as follows:

There is, of course, an extra loss of weight in stripping a paraffined cheese equal to the quantity of wax adhering to it. This need not be more than 4 or 5 ounces. If the grocer has a paraffined cheese in his possession a week before it is cut he will gain more in the saving of shrinkage than is lost in the stripping of the cheese, or in the shrinkage afterwards. When these things are better understood and the advantages of paraffining are fully realized, the objections now raised should be more than offset.

In our storage experiments the influence of paraffin upon the quality of cheese as shown by the scores for flavor and texture was studied.

As already stated, for this purpose one-half of the cheeses in each group were coated with paraffin, the same cheese being used in experiments on shrinkage. A summary of the scores of the paraffined and normal cheese is entered in Table V for comparison.

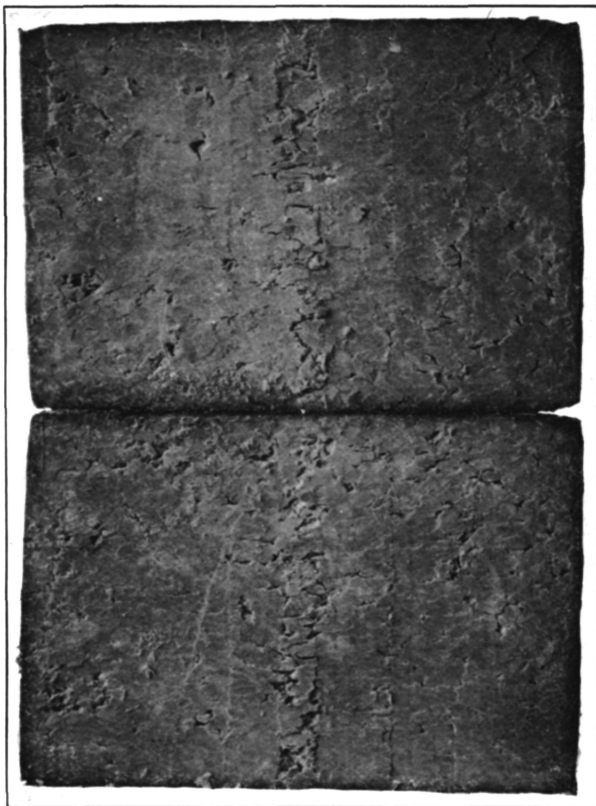
A study of the figures indicates that in the opinion of the judges there was but little difference in the quality of the natural and paraffined product. Sometimes the one scored highest and sometimes the other. Naturally the paraffin prevented to a large extent the growth of mold, thus maintaining the cheese in a clean and bright condition. The higher score for finish obtained by the paraffined cheese has a tendency to increase the total, and for this reason the paraffined product scored highest in the final average. This is brought out more clearly in the following tabulation:

TABLE VI.—*Comparison of scores of natural and paraffined cheese.*

Style of cheese.	Storage tempera- ture.	Natural.					Paraffined.				
		Oct. 12.	Dec. 14.	Feb. 15.	Apr. 14.	June 15.	Oct. 12.	Dec. 14.	Feb. 15.	Apr. 14.	June 15.
	°F.										
Cheddar	40	97.5	99.0	99.3	99.3	98.8	99.7	99.6	98.6	99.0	99.3
	34	99.5	99.1	97.8	97.1	98.2	99.0	99.7	98.3	98.7	99.0
	28	98.6	99.5	99.0	97.0	96.2	98.3	99.1	99.7	98.0	98.0
	5				80.0						
	40	96.2	95.2	95.2	92.8	92.3	97.0	96.2	93.8	92.2	92.3
Flat	34	97.5	94.7	93.1	93.4	95.2	97.5	94.3	92.7	91.1	91.7
	28	98.2	97.0	94.0	88.8	88.3	96.7	95.7	93.8	94.9	89.7
	5									80.0	
	Oct.26						Oct.26				
	40	98.8	99.7	99.0	98.1	97.9	98.0	99.5	99.3	98.1	98.3
Young America	34	98.0	99.7	97.5	98.2	97.5	97.8	99.7	98.5	98.6	98.5
	28	98.1	99.7	96.8	96.0	96.3	98.5	99.7	97.8	97.7	98.0
	5									85.0	

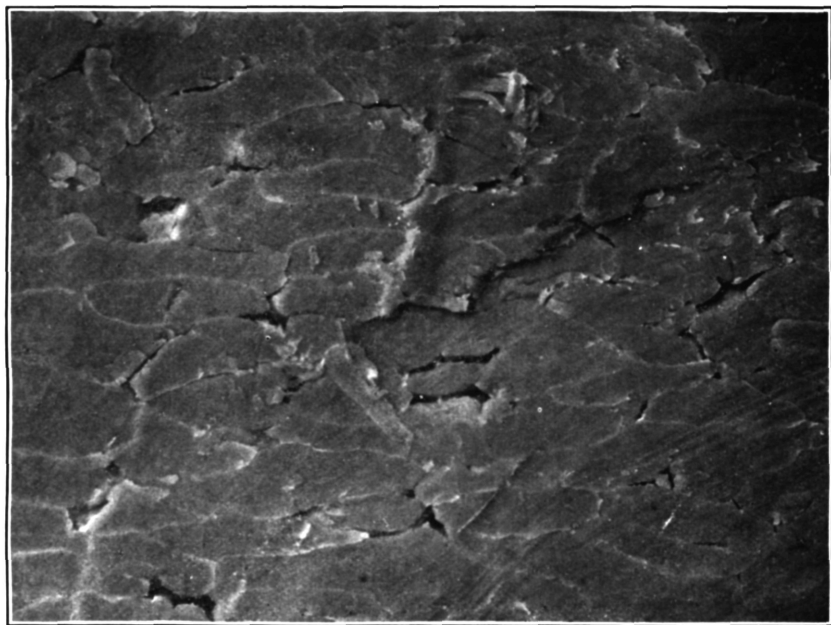
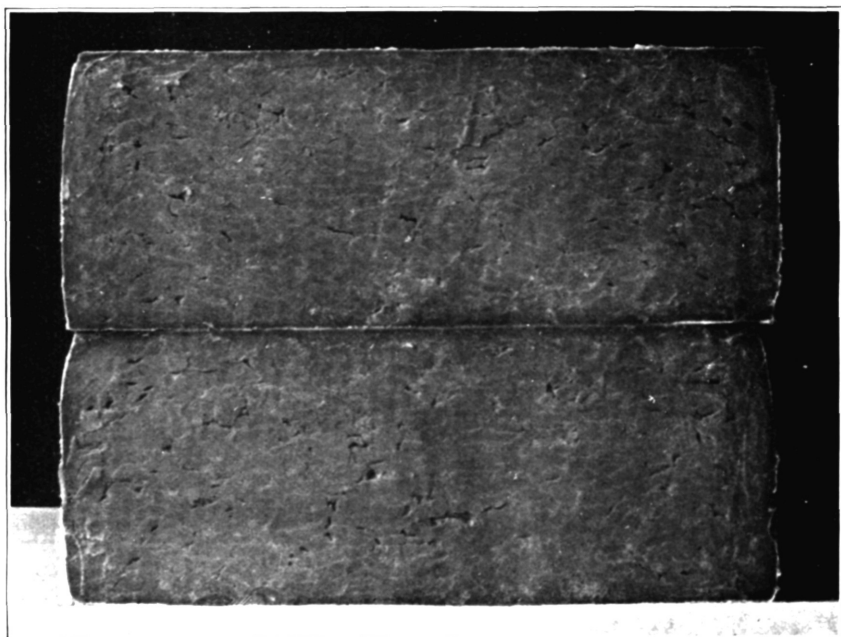
EFFECT OF FREEZING ON THE QUALITY.

In addition to the experiments at the higher temperatures, it was thought desirable to store a small quantity at a freezing temperature, in order to determine the general effects of freezing on the quality. For this purpose 3 Cheddars weighing 203 pounds 11 ounces, 3 Flats weighing 111 pounds 15 ounces, and 4 Young Americas weighing 41 pounds 14 ounces, were placed in storage at 5° F. One each of the Cheddars and Flats and two of the Young Americas were paraffined. The Cheddars and Flats were placed in storage October 12 and the Young Americas October 26. As was expected, the cheese immediately froze hard, ice showing on the surfaces, and after a time the tops and sides appeared to be lumpy, indicating that the cheese was being disintegrated by the cold. The judges found it impossible to bore these cheeses at the time the others were inspected, and they were therefore allowed to remain until April 18, six months after being placed in storage, when they were taken out and kept at a temperature of about 70° F. until thoroughly thawed out. The frozen cheese cut well and presented at first a very natural appearance. The surfaces, however, dried faster than is usual with cut cheese, and in case



SECTIONS OF CHEDDAR CHEESE AFTER FIVE AND ONE-HALF MONTHS' STORAGE AT 5° F. (FROZEN).

[Lower figure shows small section of above cheese at natural size.]



SECTIONS OF "FLATS" AFTER FIVE AND ONE-HALF MONTHS' STORAGE AT 5° F.
(FROZEN).

[Lower figure shows small section of above cheese at natural size.]

of the Cheddar type there was a marked tendency to crumble. As would naturally be expected, the low temperature prevented the cheese from ripening, and the flavor was by no means attractive. The frozen flavor and the disintegration of the curd are serious and fatal defects, so far as handling the cheese commercially is concerned, as such cheese can be sold only at a greatly reduced price.

When this cheese was scored a number of dealers in the trade were invited to come and inspect it, but there was little interest manifested. Of the three types the Young Americas showed much better than the others, both as to texture and flavor, but even these had an insipid taste and were in a crumbly condition. Another effect noted in the frozen cheese was its mottled appearance. This was not shown in the cheese stored at any of the other temperatures.

The following tabulation shows the score of frozen cheese after six months' storage, as reported by the judges:

TABLE VII.—*Score of cheese stored at 5° F.*

Style of cheese.	Texture.	Flavor.	Color.	Finish.	Total.
Cheddar.....	40	20	10	10	80
Flat.....	40	20	10	10	80
Young America.....	40	20	15	10	85

GENERAL SUMMARY.

This work was designed as distinctly a storage experiment, having little regard for the question of curing. The principal object was to answer the question, How do different temperatures affect the weight and quality of cheese stored for considerable periods? The fact was also kept in mind while these experiments were in progress that the chief purpose in storing cheese commercially is to make a profit. It is believed that some valuable information has been collated as to the best temperatures for holding cheese, also in regard to the shrinkage in weight connected with such temperatures. It has also been shown that paraffining cheese is economical for storage purposes, both as to loss in weight and the general appearance of the product.

RESULTS IN REGARD TO WEIGHT.

We have seen that the storage of cheese at a temperature near the freezing point greatly reduces the loss due to shrinkage in weight as compared with that which occurs at higher temperatures, that such loss is still further prevented by covering cheese with paraffin, and that the combination of these two conditions reduces the shrinkage to a minimum.

Less shrinkage as a result of using low temperatures.—On the basis of the longest period of time for which we were able to compare the results at the different temperatures employed (247 days for Cheddars

and Flats and 233 days for Young Americas), it was found that the Cheddar type stored at 40° F. had lost on an average 5.87 pounds for 100 pounds of cheese, the cheese at 34° F. had lost 5.12 pounds, and that at 28° F. 2.88 pounds. For 100 pounds of cheese originally placed in the storage rooms at the different temperatures we had for sale at the end of the storage period 94.13 pounds of cheese stored at 40° F., 94.88 pounds stored at 34° F., and 97.12 pounds stored at 28° F. Assuming that the cheese sold at a uniform price of 10 cents a pound (it having been shown that the scores were not materially different), the receipts from the original 100 pounds of the cheese at the different temperatures would be as follows:

Cheddars stored at 40° F.....	\$9.41
Cheddars stored at 34° F.....	9.49
Cheddars stored at 28° F.....	9.71

Under these conditions the receipts from the cheese stored at 28° F. are 22 cents per 100 pounds more than from that stored at 34° F. and 30 cents more than from that stored at 40° F. With the use of paraffin, as shown later, the differences are even greater.

Following the same methods in presenting the results with the Flats, we find that at 40° F. this class of cheese has lost on an average 5.53 pounds for 100 pounds of cheese; at 34° F., 4.37 pounds, and at 28° F., 2.19 pounds. For 100 pounds of cheese originally placed in the storage rooms at the different temperatures we therefore had for sale at the end of the storage period 94.47 pounds of cheese stored at 40° F., 95.63 pounds stored at 34° F., and 97.81 pounds stored at 28° F. Assuming here also that the cheese sold at a uniform price of 10 cents a pound, the receipts from the original 100 pounds of this cheese at the different temperatures would be as follows:

Flats stored at 40° F.....	\$9.45
Flats stored at 34° F.....	9.56
Flats stored at 28° F.....	9.78

The receipts, therefore, for the cheese stored at 28° F. would be 22 cents per 100 pounds more than for that stored at 34° F. and 33 cents more than for that stored at 40° F.

Again a similar consideration of the Young Americas shows that at 40° F. this class lost on an average 9.34 pounds for 100 pounds of cheese; at 34° F. the loss was 6.95 pounds, and at 28° F. 4.25 pounds. For 100 pounds originally placed in the storage rooms at the different temperatures we had for sale at the end of the storage period 90.66 pounds of cheese stored at 40° F., 93.55 pounds stored at 34° F., and 95.75 pounds stored at 28° F. Assuming again the same selling price for this cheese as for the others, the receipts for the original 100 pounds at the different temperatures would be as follows:

Young Americas stored at 40° F.....	\$9.06
Young Americas stored at 34° F.....	9.30
Young Americas stored at 28° F.....	9.57

On this basis the receipts for the cheese stored at 28° F. would be 27 cents per 100 pounds more than for that stored at 34° F., and 51 cents more than for that stored at 40° F.

Influence of size and type of cheese.—The three types of cheese in this experiment—namely, Cheddars, Flats, and Young Americas—weighed on an average 68, 37.7, and 10.4 pounds, respectively. It would naturally be expected that the three kinds would vary somewhat in the amount of shrinkage. The results on this point show that at the 40° F. temperature there was not a great difference in the loss for Cheddars and Flats, the amount for the entire storage period (eight months) being 5.87 and 5.53 per cent, respectively. The Young Americas, however, which were much smaller, lost 9.34 per cent. A similar variation is shown at the other temperatures.

Influence of paraffin.—At the end of eight months the Cheddar cheese coated with paraffin had lost only 3.19 pounds for each 100 pounds of cheese originally placed in storage at 40° F., 1.36 pounds at 34° F., and 1.27 pounds at 28° F. The saving thus effected, based on the price of cheese at 10 cents a pound, would average about 27 cents for 100 pounds of cheese stored at 40° F., 38 cents per 100 pounds at 34° F., and 16 cents per 100 pounds at 28° F. This small saving at the 28° F. temperature is due to the fact that the loss in weight was very small where no paraffin was used, and while the paraffin reduced this loss still further, the effect is not as marked as in the case of the higher temperatures. Comparing these results where the greatest saving was effected, namely, the combination of the 28° F. temperature with paraffining as against the 40° F. temperature without paraffining, we have a difference of 46 cents per 100 pounds in favor of the former.

The Flats gave a similar result, the saving with paraffined cheese at 28° F., as compared with natural cheese at 40° F., being the same—about 46 cents.

In the case of the Young Americas the saving was more marked, this cheese having lost only 2.38 pounds per 100 pounds at 40° F., 2.11 pounds at 34° F., and 1.45 pounds at 28° F. Comparing the cheese kept at 40° F. not covered with paraffin with that at 28° F. covered with paraffin, there would be a difference of about 52 cents per 100 pounds in favor of the paraffined product at the low temperature.

RESULTS IN REGARD TO QUALITY.

The cheese was carefully scored by three judges every two months, and the results in detail have been given in preceding tables. It is only necessary here to state their findings in a general way.

Group I, Cheddars.—This group showed excellent keeping quality during the whole eight months. At the first scoring, which took place after two months' storage, the cheese at the three temperatures, namely,

28°, 34°, and 40° F., scored 99.5, 99.1, and 99, respectively. At the second, third, and fourth scorings the cheese at 40° F. rated the highest, and the final average for the four scorings at each of the temperatures of 40°, 34°, and 28° F. are 99.1, 98.05, and 97.9, respectively.

Group II, Flats.—This type of cheese showed some deterioration at all temperatures, even at the first scoring, and gradually continued to fall off in quality until the close of the storage period. That stored at 34° F. gave the highest average for the four scorings, namely, 94.1 against 93.9 for 40° F., and 92.02 for 28° F.

Group III, Young Americas.—The cheese in this group held its quality, almost without exception, throughout the entire experiment. Here, again, as in the case of the Cheddars, the cheese at 40° F. gave the highest average score for the four inspections, namely, 98.7. This was followed closely by the cheese at 34° F. with a score of 98.2, that at 28° F. scoring 97.2.

It appears from the above statements that the different temperatures used had no very marked influence upon the quality of the cheese, and, as stated at the outset, this was one of the minor points of this experiment.

EFFECT OF PARAFFIN ON QUALITY.

One-half of each group of cheeses was paraffined just before being placed in storage; otherwise they were handled the same as unparaffined cheese. The results of the experiment indicate that the paraffining had no prejudicial effect upon any of the types of cheese at any temperature; in fact, in the case of the Cheddars and Young Americas the paraffined product scored a little the highest at all three temperatures in the final average. A similar result was recorded with the Flats at the lowest temperature, but at 34° and 40° F. the natural cheese in this class was slightly ahead.